

Real-world Forecast Applications Utilizing Tools and Knowledge Base from a Decade of HMT-WEST

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Applying HMT-West Results to Real-World Forecast Challenges

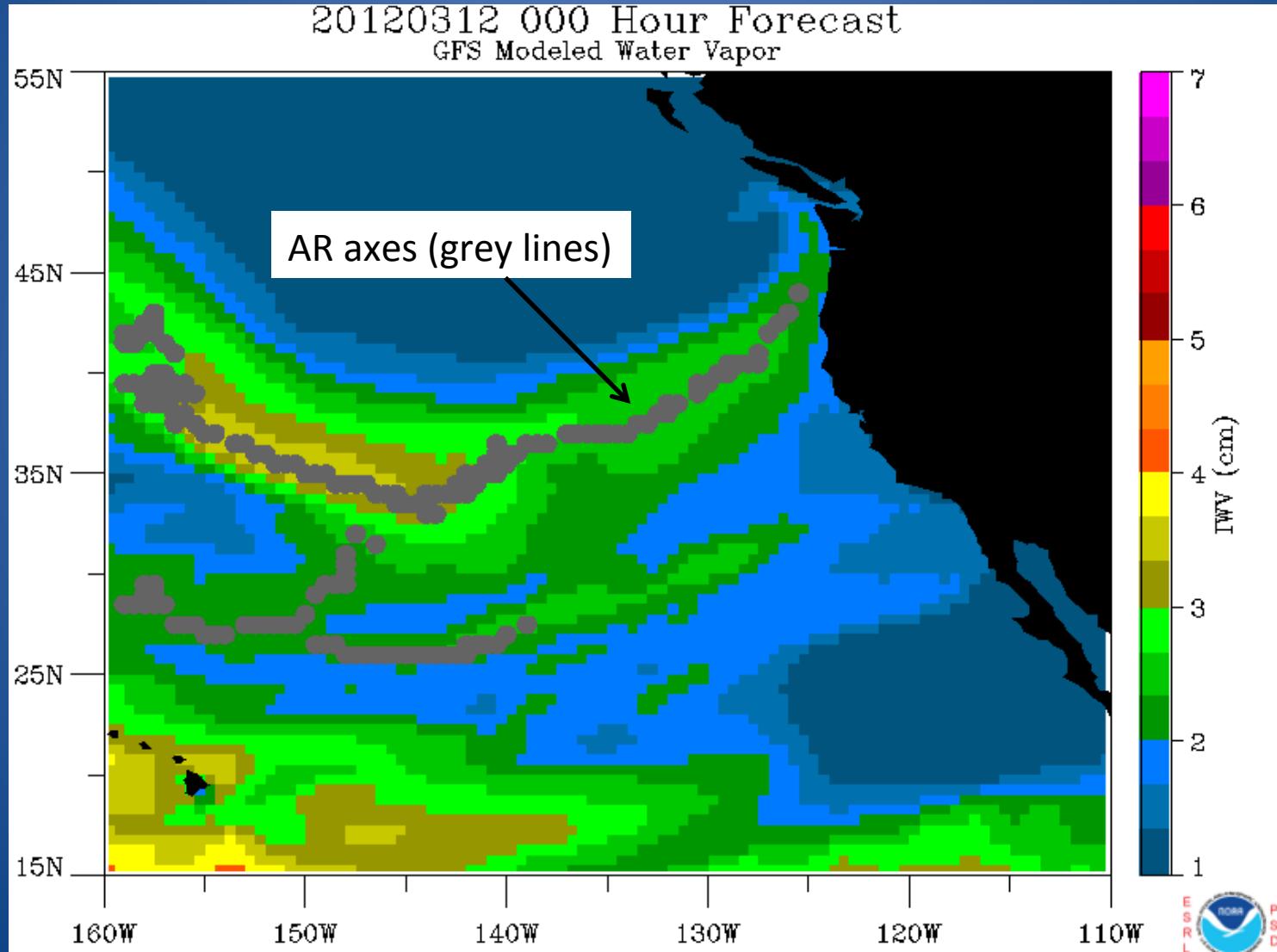
- Examine recent weather event and show how HMT results can be utilized in forecast process
 - Part of GoTo Meeting held March 12 2012 WR SOOs
- Identify appropriate HMT observation systems for forecast lead-time
- Identify where we have made improvements in forecasting extreme events.
- Identify where challenges remain

Improved Situational Awareness

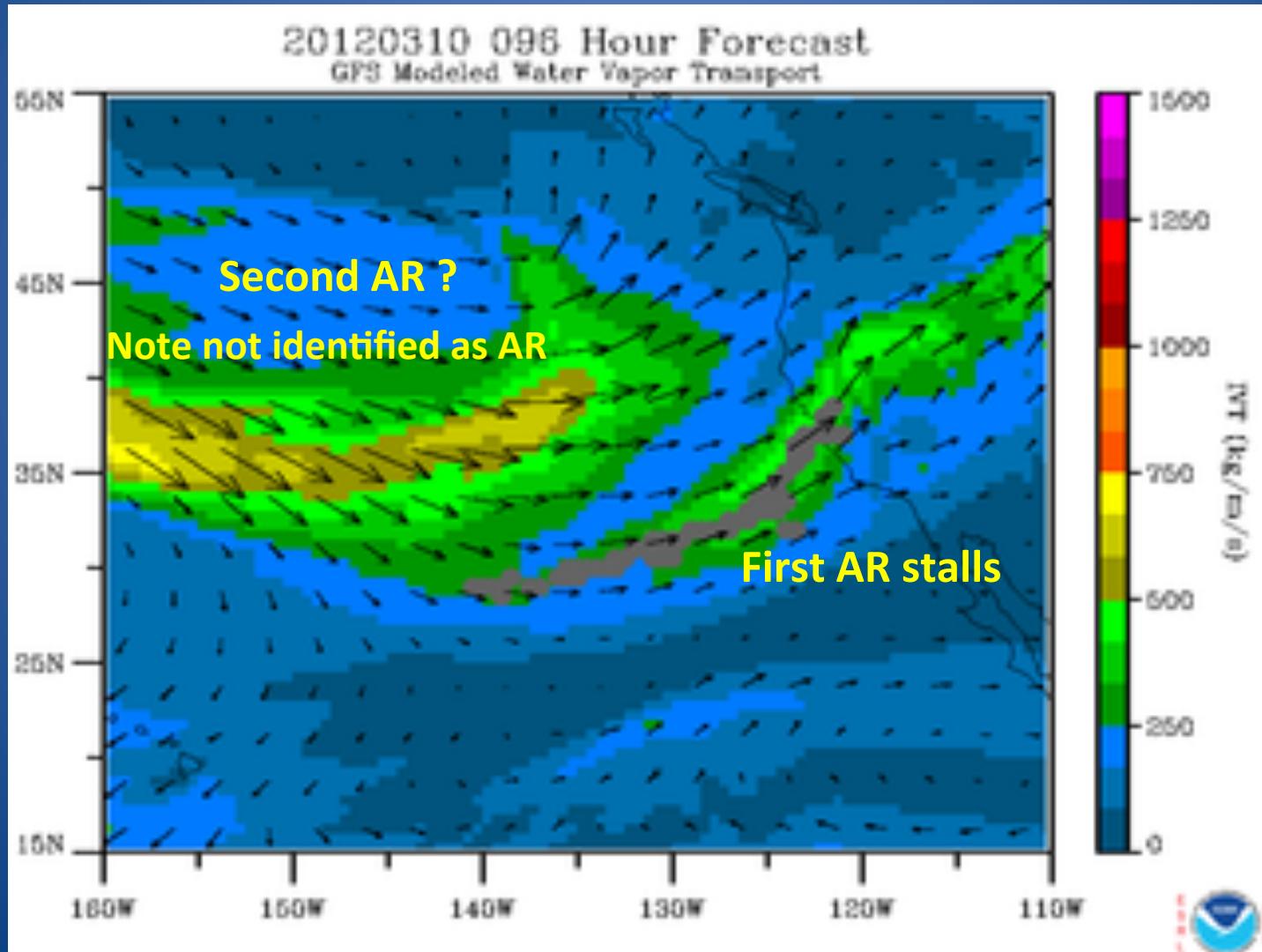
- Forecasters understand the significance of and can identify AR conditions – key result of HMT
- SSM/I/GFS combined AR detection and moisture flux tool provides excellent “heads up” of potential extreme event 1-5 days out
- Forecasters will need to calibrate these data in terms of precipitation potential
- Now being used in Western Region decision support coordination calls identifying upcoming “significant events”

Objectively ID'd AR Monday

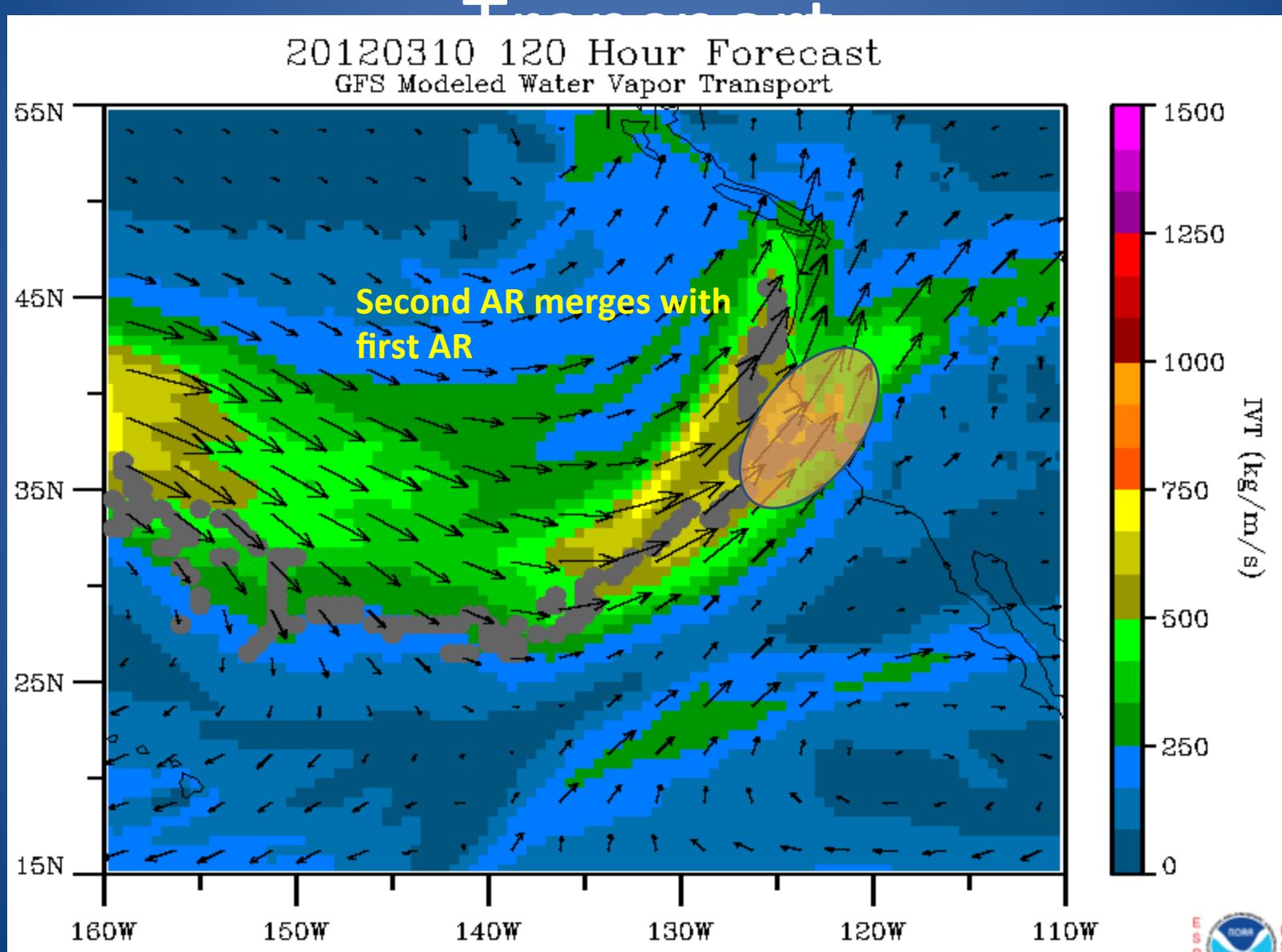
12 March 2012



Combined AR detection and GFS winds to create moisture flux estimate valid 14 March 12z



120 hr Forecast Moisture



March 14, 2012 Descending Passes
SSM/I Integrated Water Vapor (Wentz algorithm)

20120314 000 Hour Forecast
GFS Modeled Water Vapor

**SSM/I Observed "4-7"
rain\24 hrs**

GFS Model Analysis

"AR Detection Tool"

example from
14 March 2012

Wick et al., 2012, IEEE Trans.
Geosci. Remote Sensing
(in revision March 2012)

Satellite observations +
GFS Model analysis

GFS Model Forecasts all
valid at the same time, but
from different lead times

Gives forecaster some
level of uncertainty – very
typical of variability in
location of land-fall 1 day
out

20120313 024 Hour Forecast
GFS Modeled Water Vapor

20120312 048 Hour Forecast
GFS Modeled Water Vapor

GFS 1-day forecast

GFS 2-day forecast

20120309 120 Hour Forecast
GFS Modeled Water Vapor

20120307 168 Hour Forecast
GFS Modeled Water Vapor

GFS 5-day forecast

GFS 7-day forecast

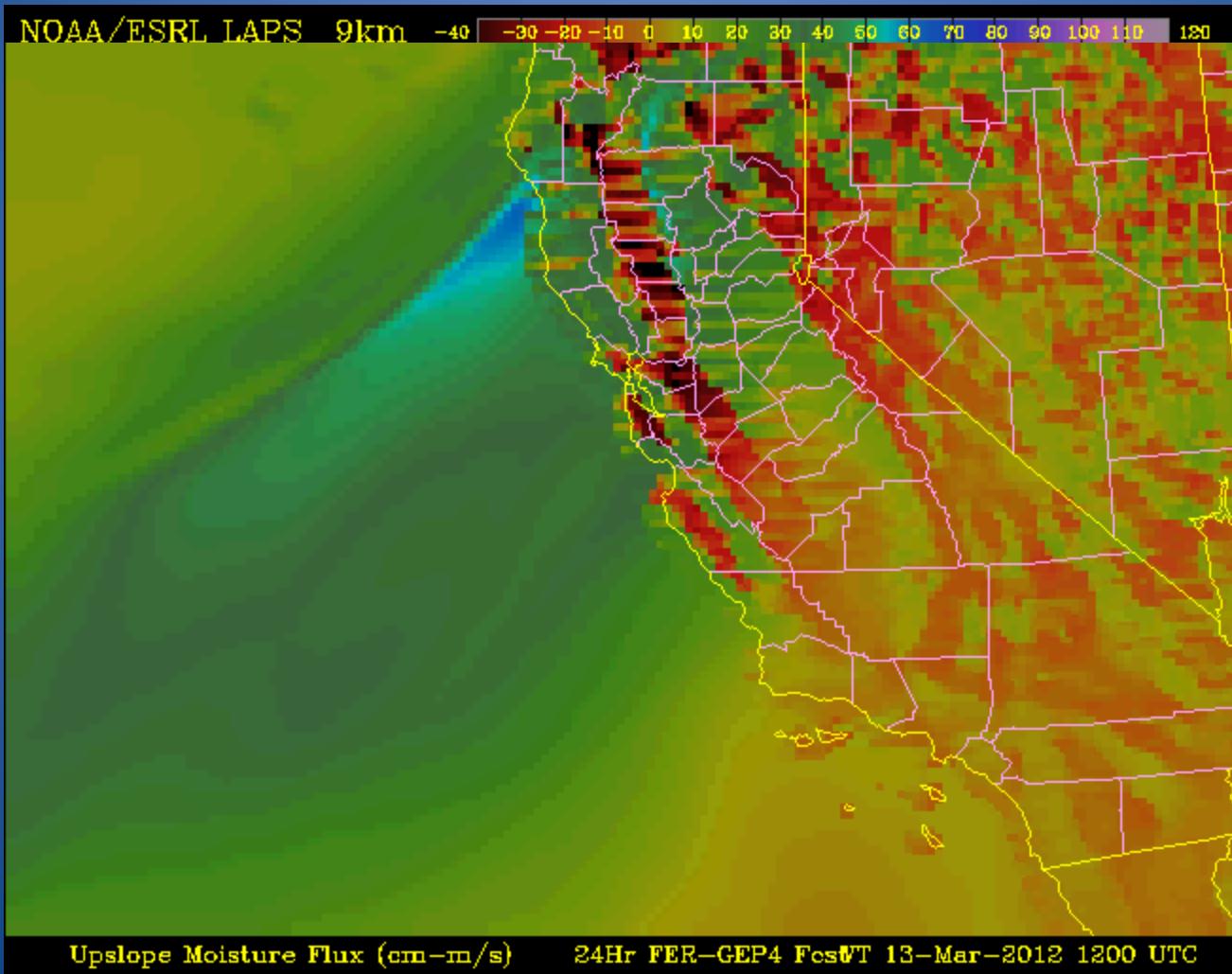
160W 150W 140W 130W 120W 11

160W 150W 140W 130W 120W 110W

Moisture Flux identifies stalling AR

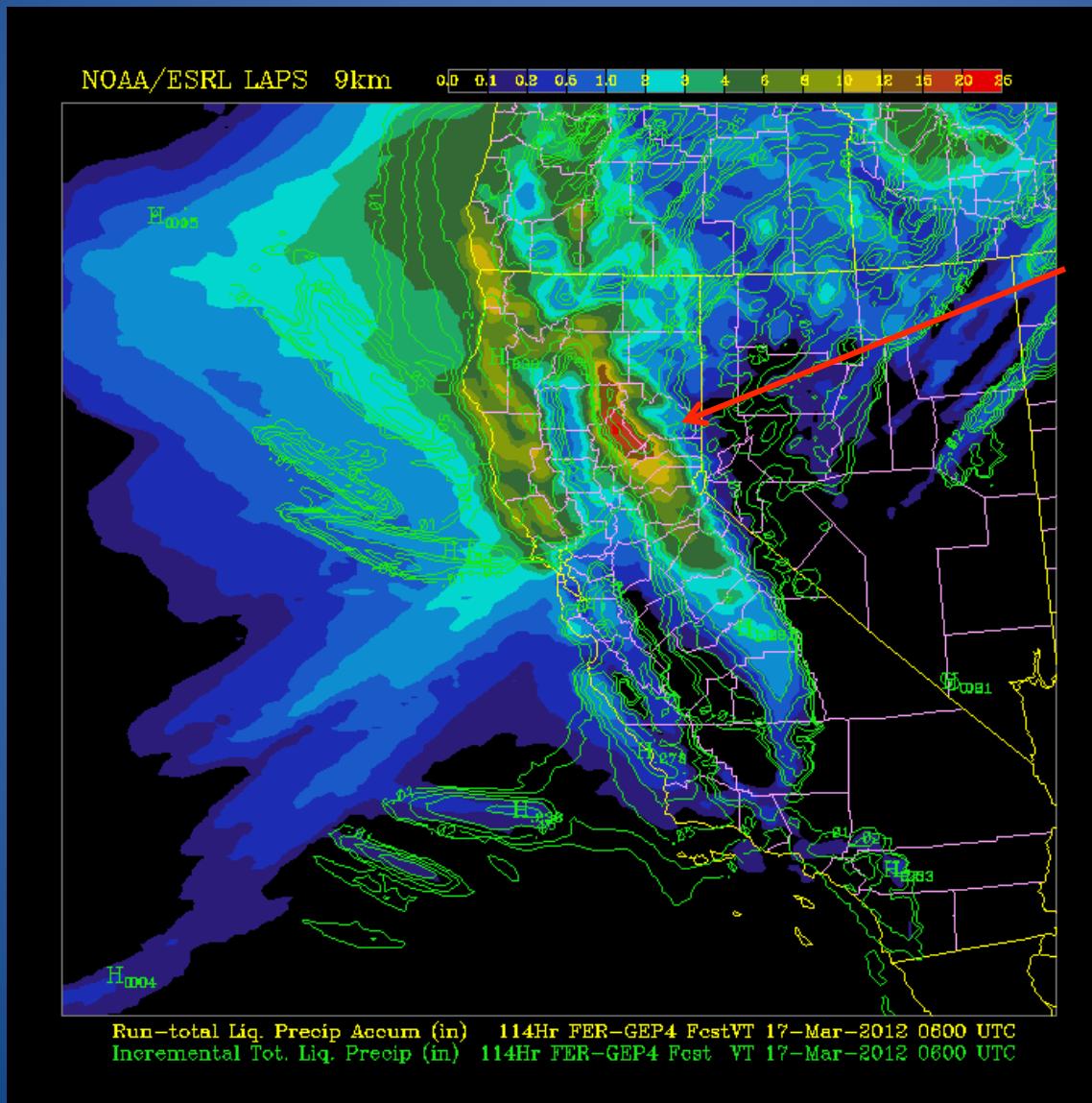
Special Flux Diagnostic using Neiman

Results



120 hr Precip from 12z 12 March 2012

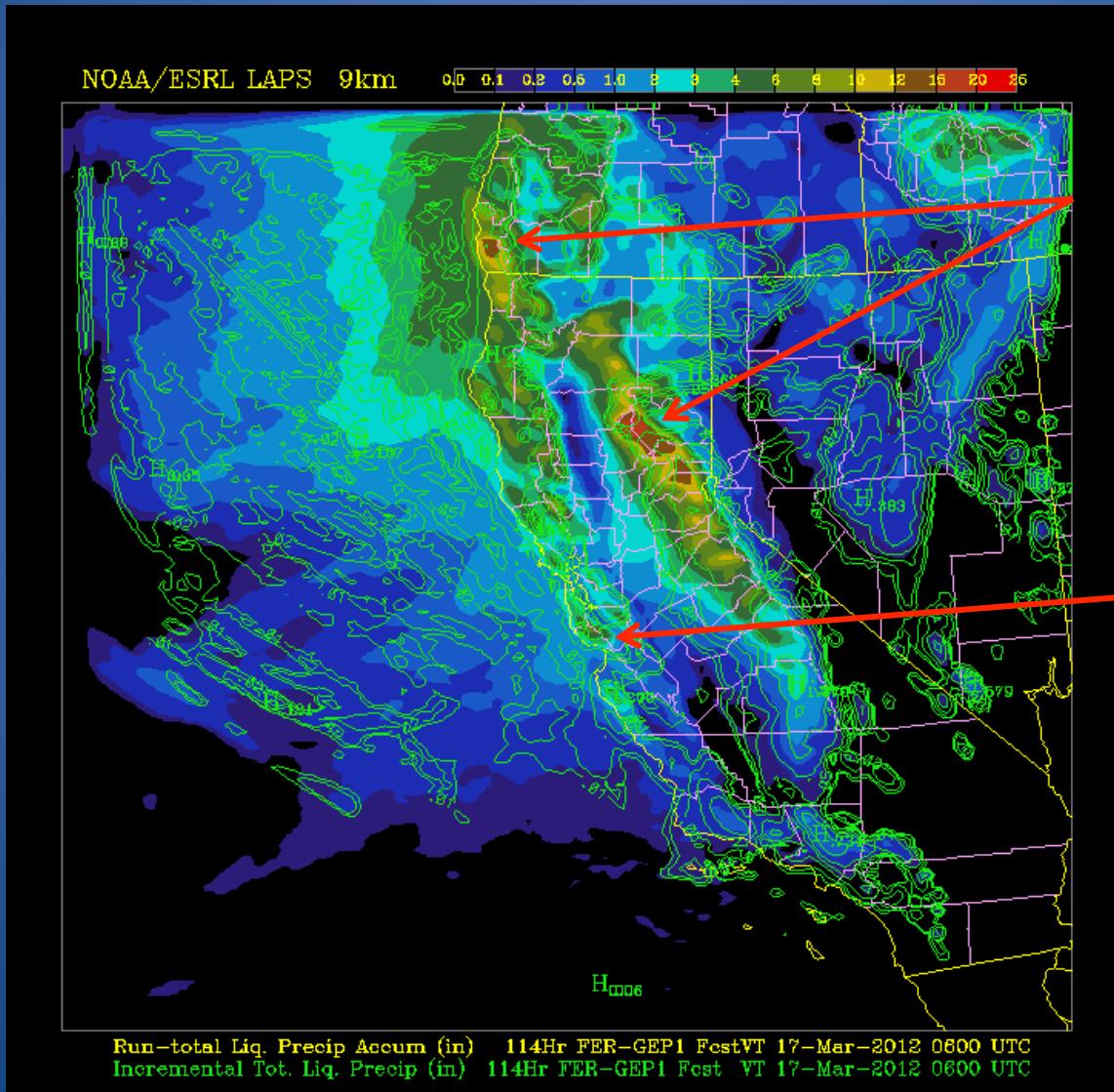
Ferrier Microphysics - NMM Core



Combination
of 1st and 2nd
AR's >15"

120 hr Precip from 12z 12 March 2012

Ferrier ARW core



Combination
of 1st and 2nd
AR's >15"

Note this shows
heavier rainfall
in Santa Cruz
Mtns.

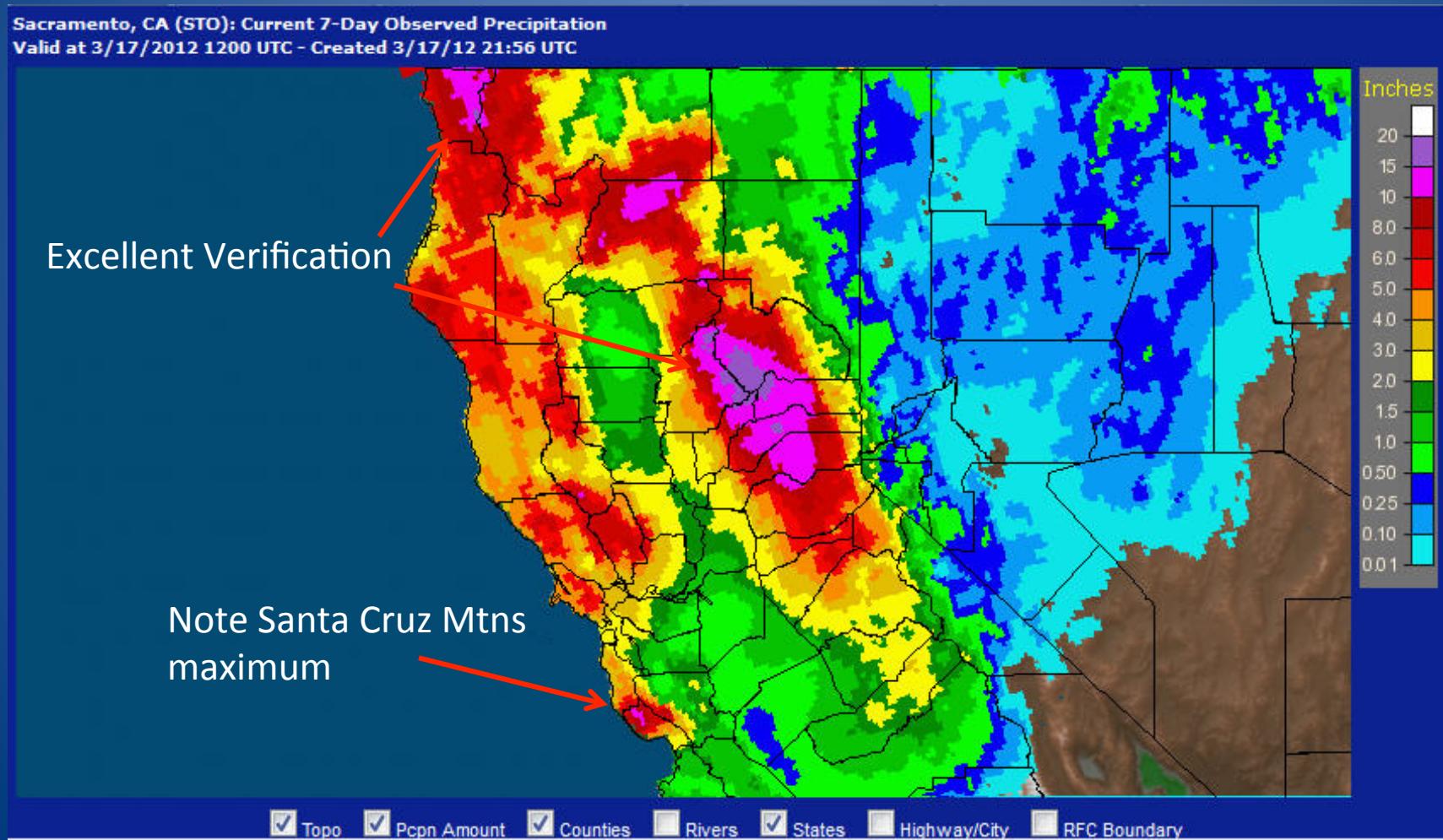
Forecast Snowfall Totals



Can Forecaster Believe Model QPF Impacts if Real

- Understand land-falling AR impacts on QPF
- Understand significance of stalling AR
- Impacts of AR on average snow-level – usually above climatological normal – warm air advection – maybe snow accum overdone below 8 k ft?
- Temporal distribution of rainfall – antecedent soil moisture – snow level – reservoir operating curve -flooding potential
- No significant flooding expected in Nor Cal
- Significant improvement in water supply!

120 hr Rainfall Observed

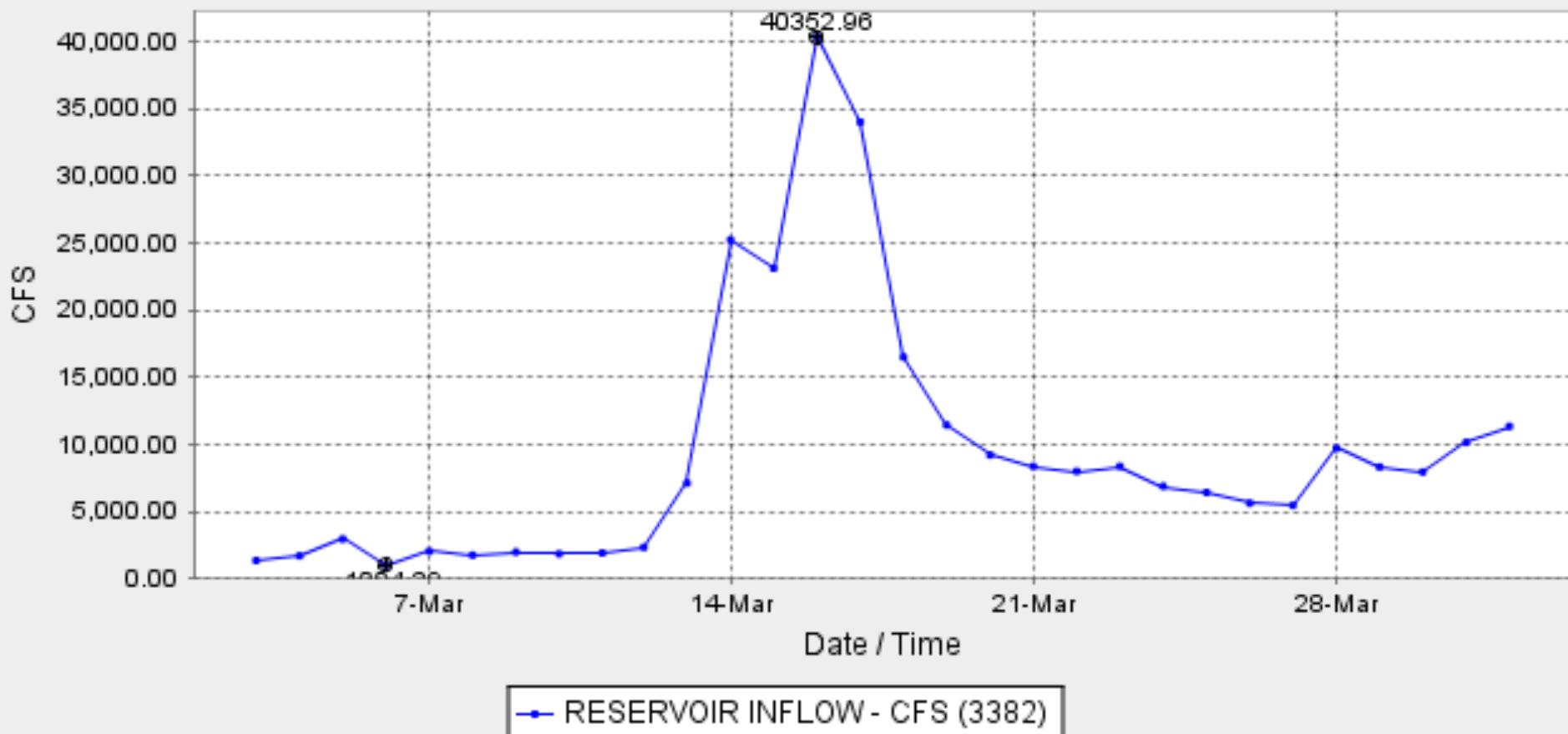


Inflow to Major State Reservoir

OROVILLE DAM (ORO)

Date from 03/02/2012 19:55 through 04/01/2012 19:55 Duration : 29 days

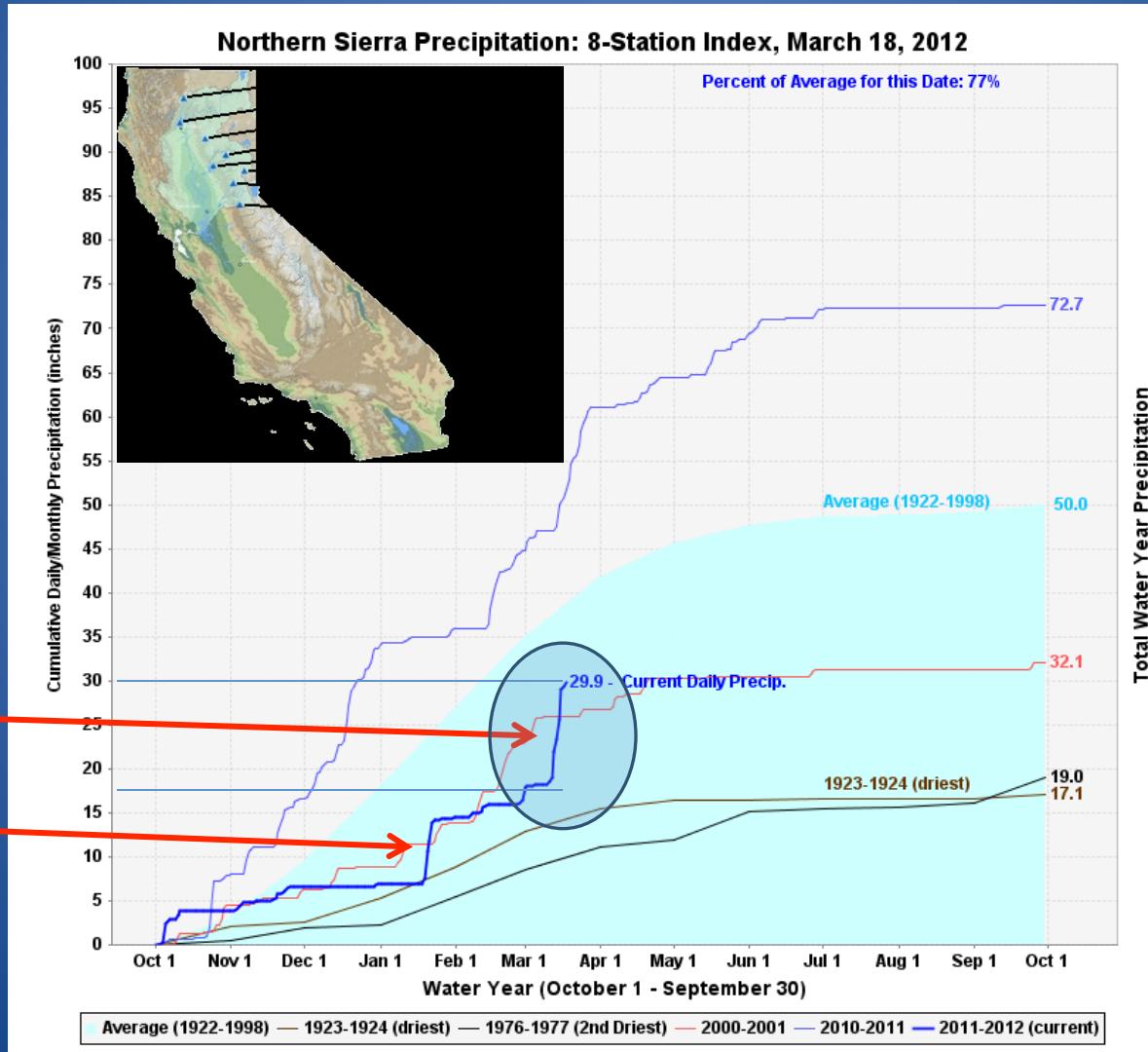
Max of period : (03/16/2012 00:00, 40352.96) Min of period: (03/06/2012 00:00, 1004.29)

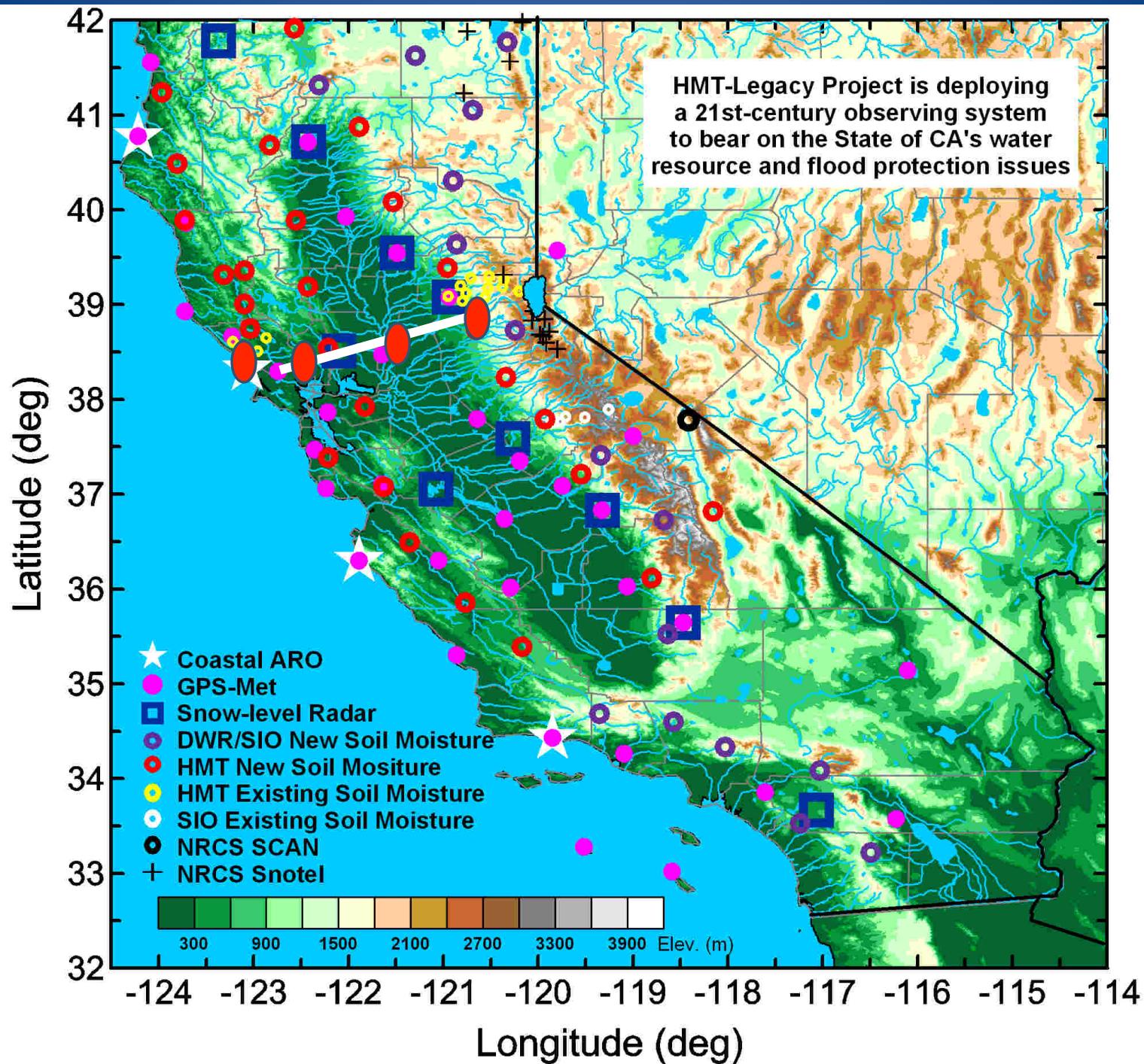


Change in 8-station Index March 2012

March
AR Landfall

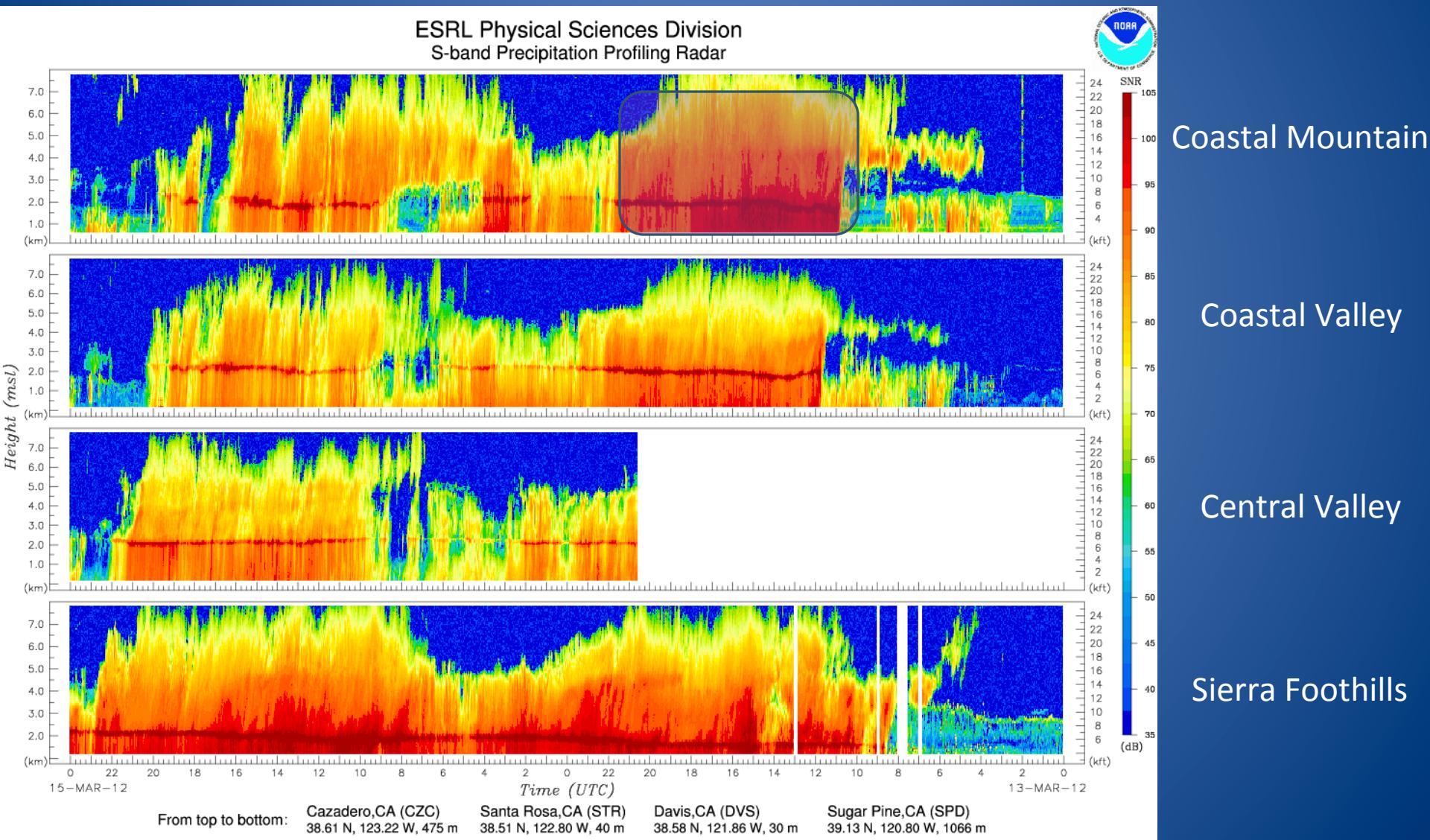
January
AR Landfall





Auto Update Display of S-Band Radars

Perfect for Office SA Displays

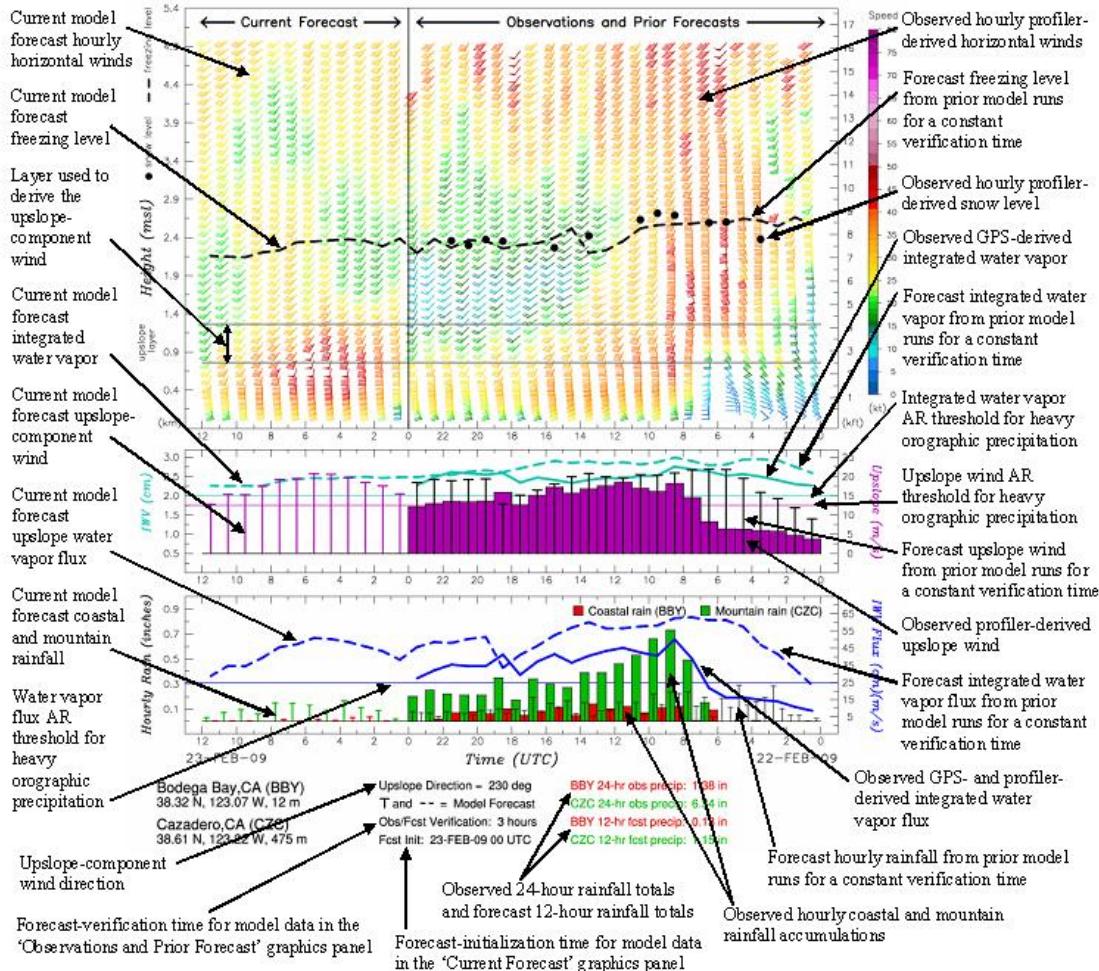


Coastal Atmospheric River (AR) Monitoring and Early Warning System

Profiler and precipitation observations provided by the NOAA/ESRL Physical Sciences Division
 GPS observations and model forecast provided by the NOAA/ESRL Global Systems Division



Training sheet posted in NWS Forecast Offices

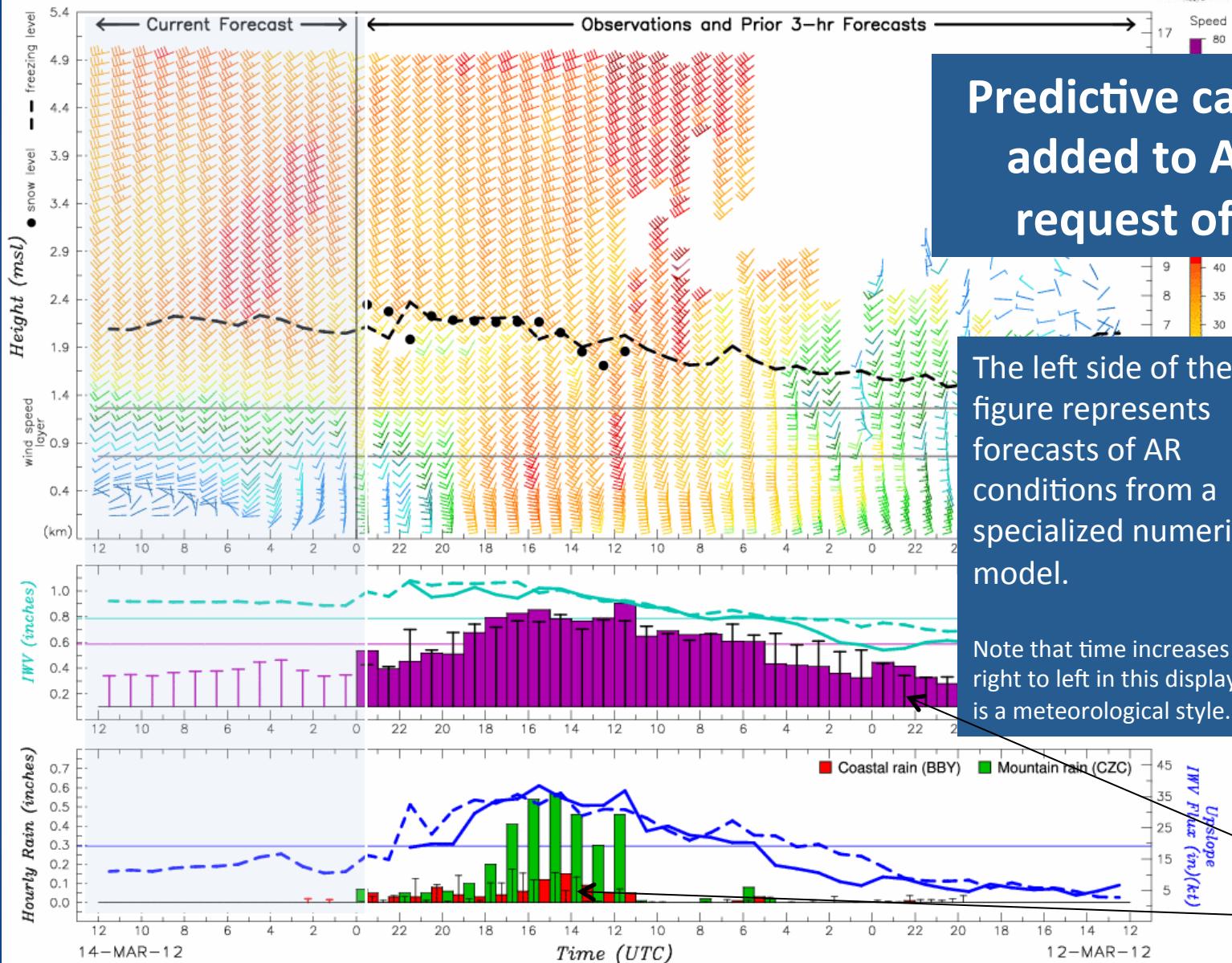


References

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- Neiman, P.J., A.B. White, F.M. Ralph, D.J. Gottas, and S.I. Gutman, 2009: A water vapor flux tool for precipitation forecasting. *Water Management*, **162**, WM2, doi: 10.1630/wama.2009.162.2.83.
- Neiman, P.J., F.M. Ralph, A.B. White, D.E. Kingsmill, and P.O.G. Persson, 2002: The statistical relationship between up-slope flow and rainfall in California's coastal mountains: Observations during CALJET. *Mon. Wea. Rev.*, **130**, 1468-1492.
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- White, A.B., D.J. Gottas, E.T. Strem, F.M. Ralph, P.J. Neiman, 2002: An automated brightband height detection algorithm or use with Doppler radar spectral moments. *J. Atmos. Oceanic Technol.*, **19**, 687B697.
- Yuan, H., J.A. McGinley, P.J. Schultz, C.J. Anderson, and C. Lu, 2008: Short-range precipitation forecasts from time-lagged multimodel ensembles during the HMT-West-2006 Campaign. *J. of Hydrometeor.*, **9**, 447-491.

ESRL Physical Sciences Division

Coastal Atmospheric River Monitoring and Early Warning System
Model forecast provided by the ESRL Global Systems Division



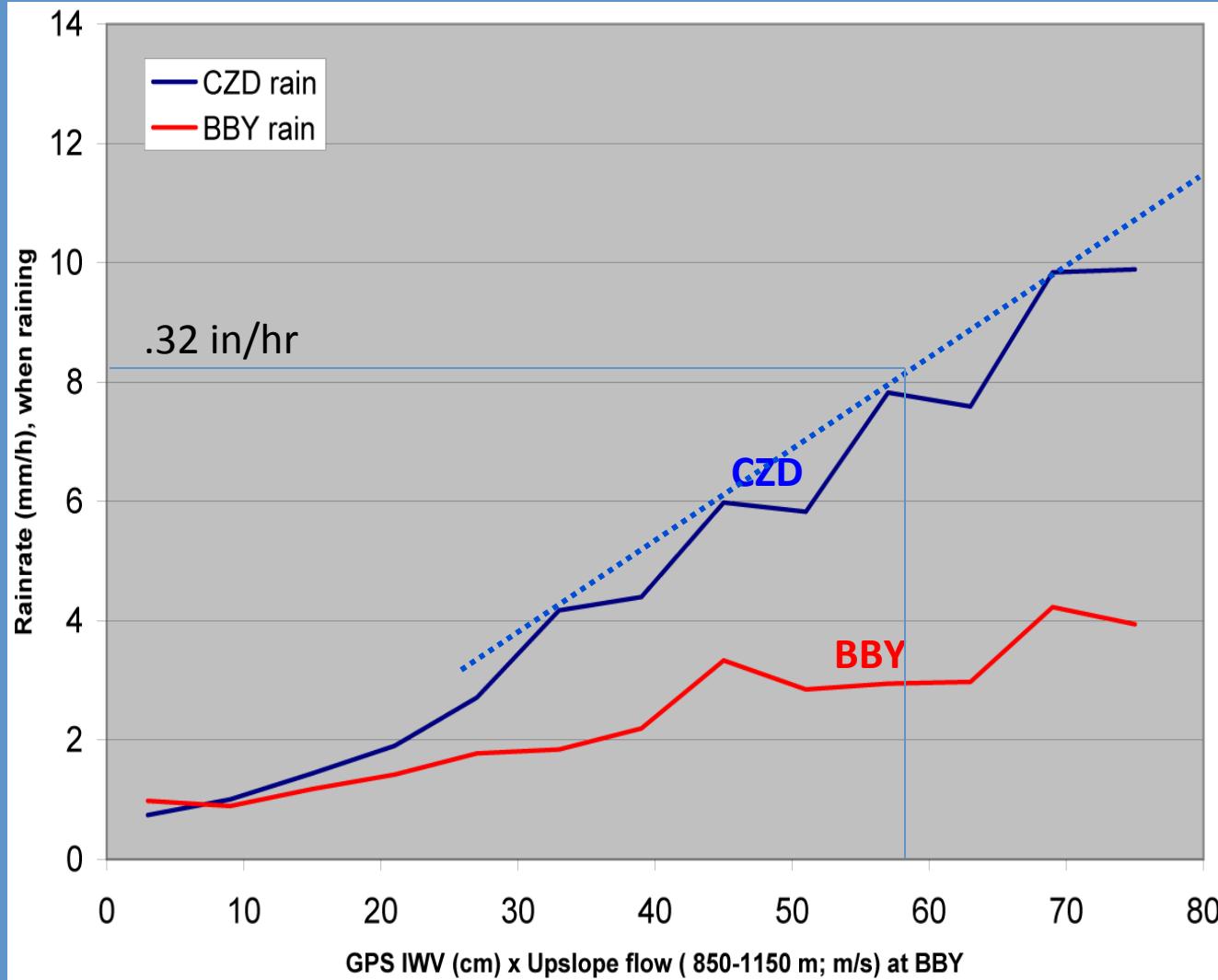
Predictive capability added to ARO at request of NWS

The left side of the figure represents forecasts of AR conditions from a specialized numerical model.

Note that time increases from right to left in this display, which is a meteorological style.

3-hr 12 km HMT WRF forecast

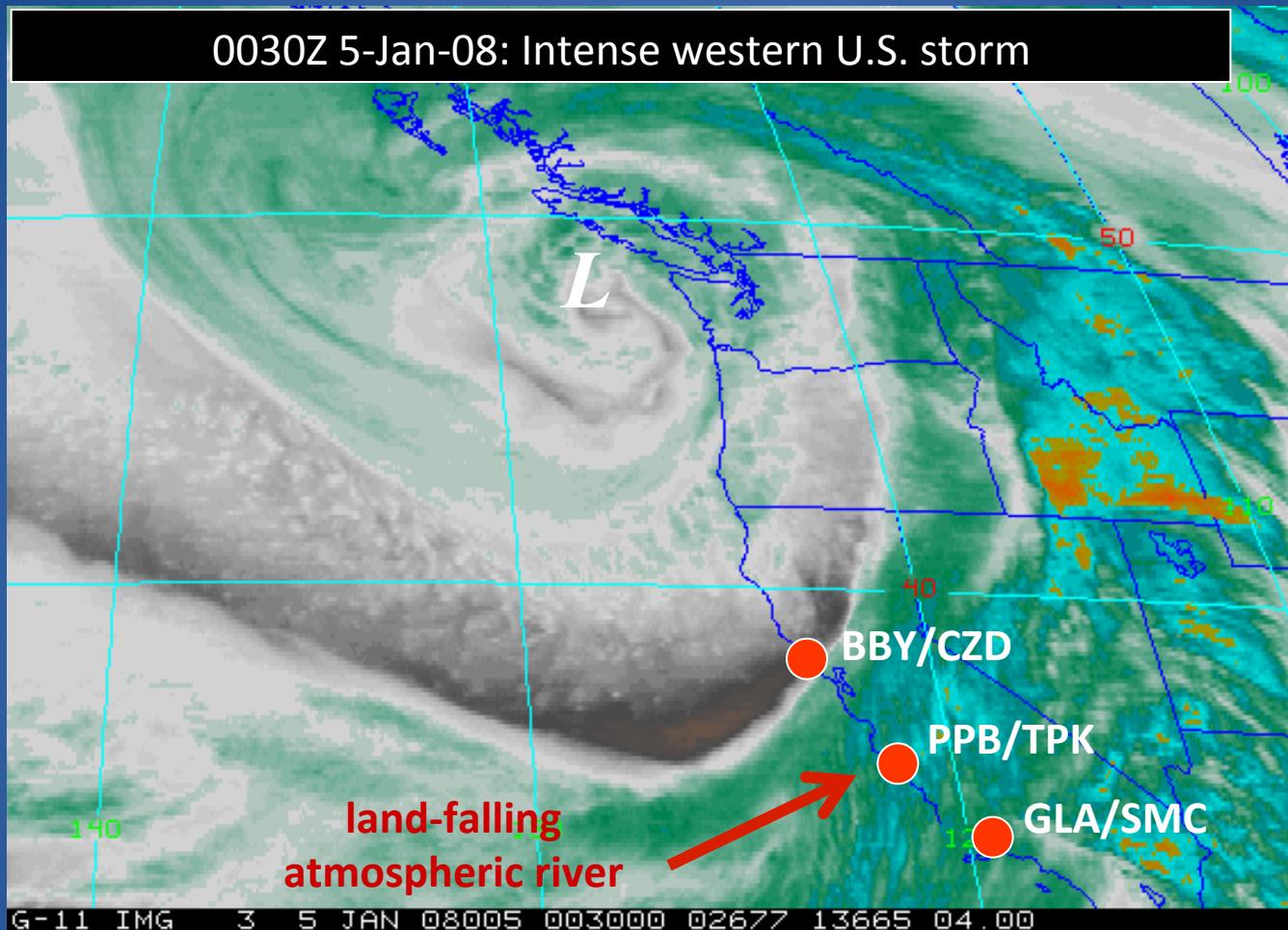
Bulk Upslope IWV Flux vs. Rainrate



Rainrate and orographic rain enhancement at CZD increases with increasing bulk upslope IWV flux,

i.e., with strengthening AR conditions

Prototype forecast tool tested at 3 CA couplets during NOAA's HMTs



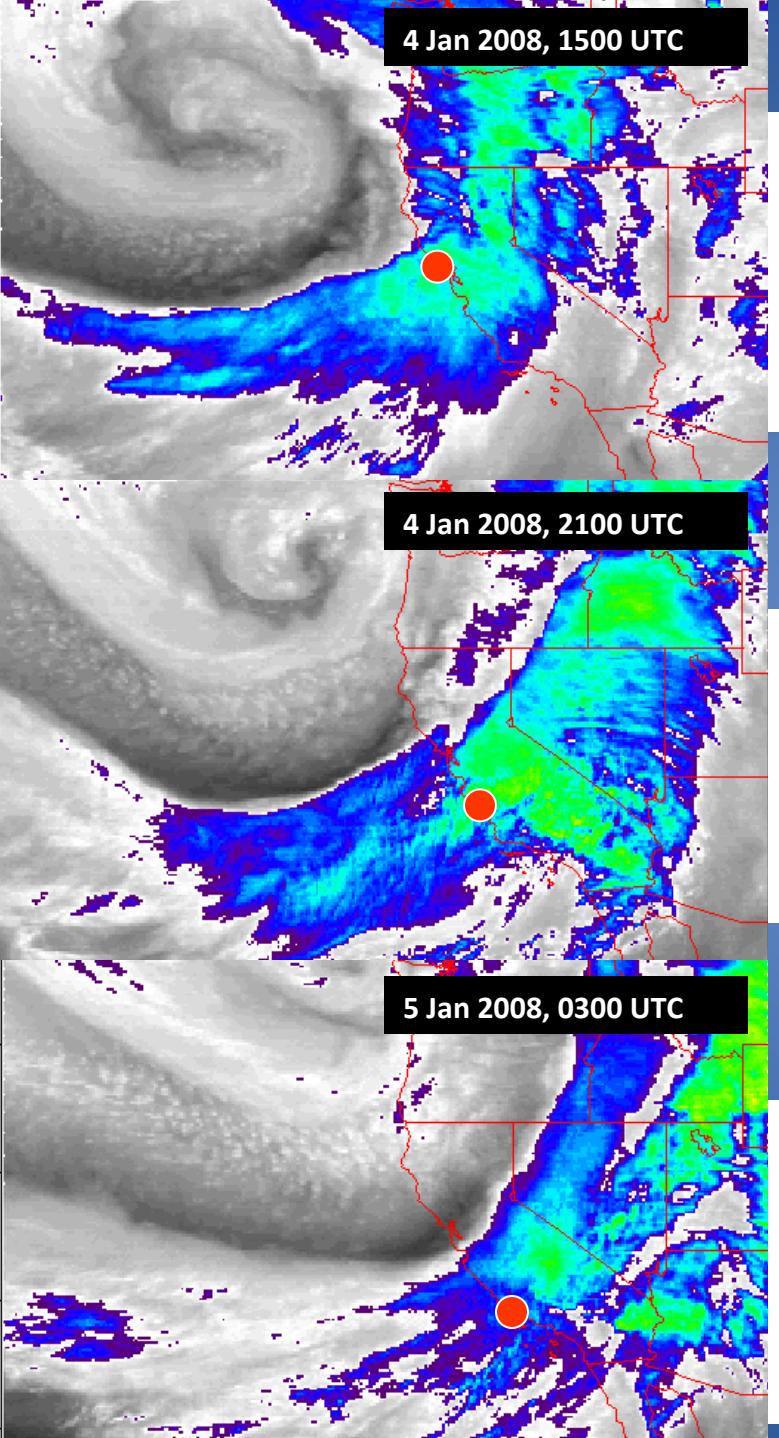
Couplets

North: Bodega Bay (BBY; 12 m MSL)
Central: Piedras Blancas (PPB; 11 m MSL)
South: Goleta (GLA; 3 m MSL)

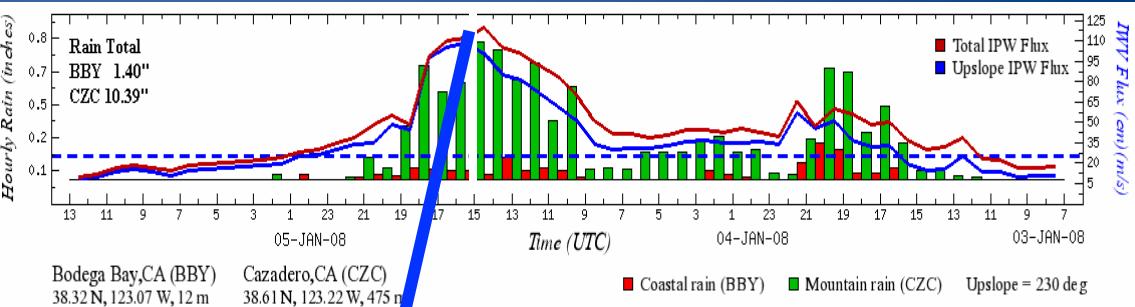
Coast (profiler, GPS, rain gauge):

Mountains (rain gauge):

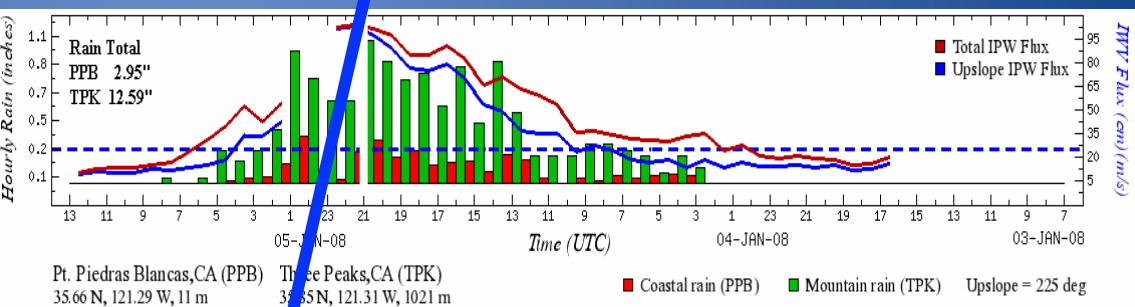
Cazadero (CZD; 475 m MSL)
Three Peaks (TPK; 1021 m MSL)
San Marcos Pass (SMC; 701 m MSL)



Time of max AR bulk flux at BBY: 1500 UTC 4 Jan

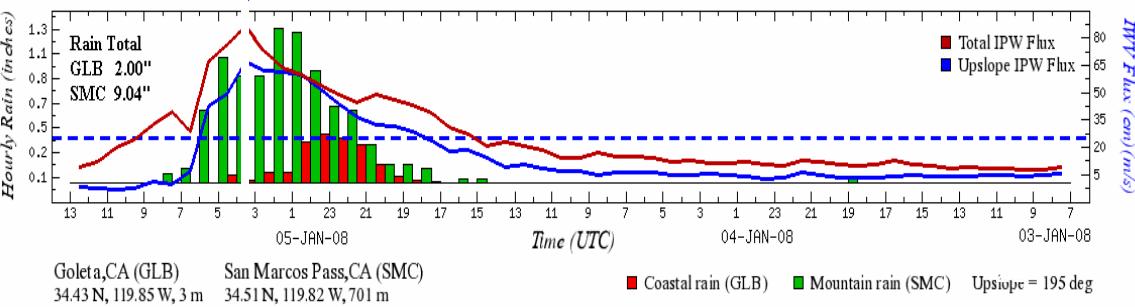


Time of max AR bulk flux at PPB: 2100 UTC 4 Jan

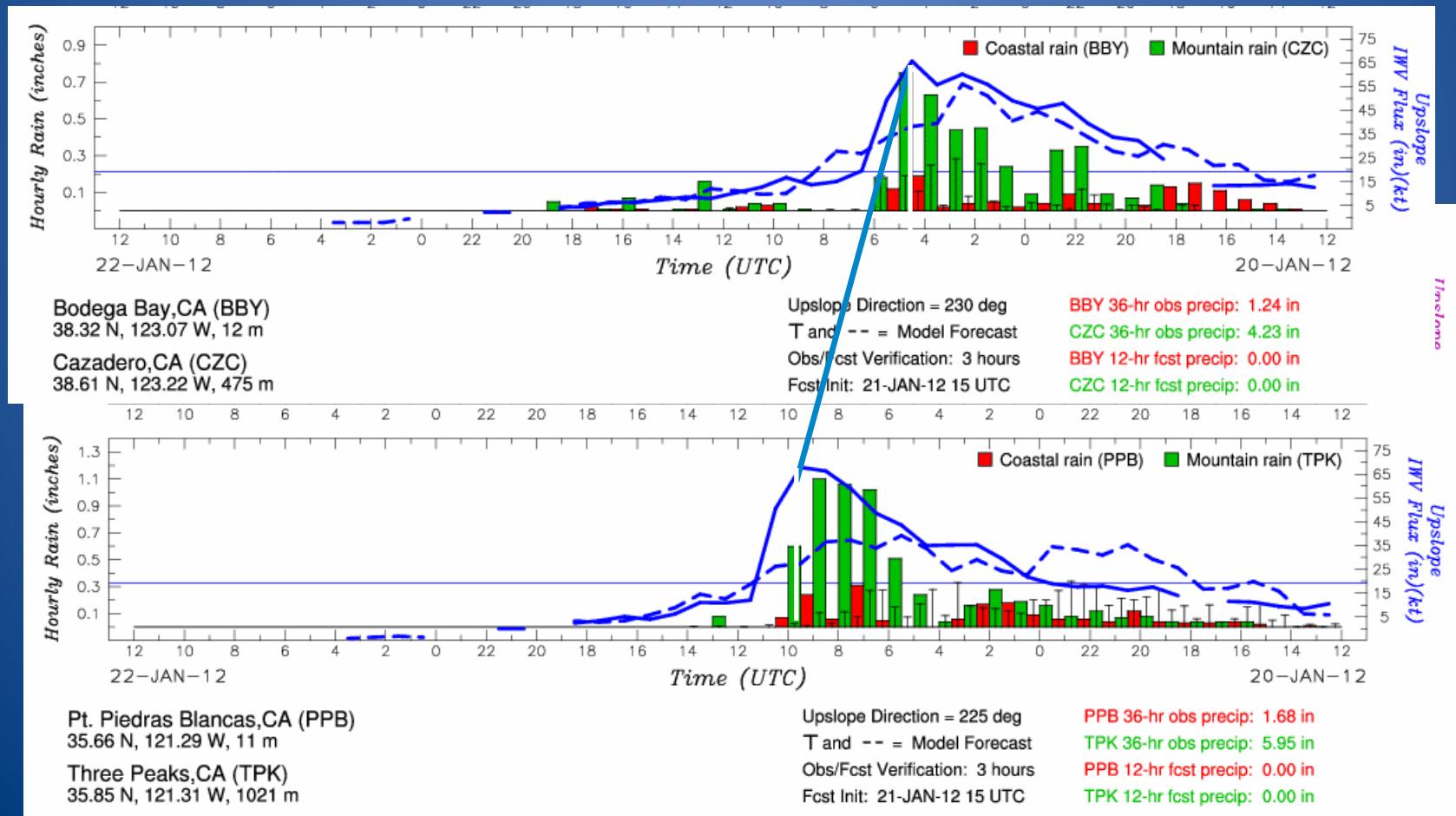


**AR Propagation: $\sim 12 \text{ m s}^{-1}$.
½-day lead time for SoCal**

Time of max AR bulk flux at GLA: 0300 UTC 5 Jan



\sim 14 m/s translation time from BBY to PPB



Key Benefits of HMT

- Major result of HMT West is educating forecasters as to the ingredients that produce extreme rainfall –
 - A key component is land-falling Atmospheric Rivers
- HMT has developed tools to improve forecaster situational awareness 5 to 7 days out which translates to improved decision support to Emergency Managers and Water Resource Agencies
- Combination of AROs along the coast and high resolution ensemble numerical modeling coupled together in a similar format allows forecasters to be aware of short term model bias and anticipate short term (0-12 hr) continuation or cessation of extreme rainfall. This is key to issuing (or not) warnings with sufficient lead-time.
- Snow level sensors significant aid to hydrologist in modeling runoff as well as to forecasters for pinpointing snow levels.

Significant Challenges Remain

- Refining the exact timing and location of extreme rainfall still difficult
 - Models still struggle with QPF for 1-6 hr time resolution
 - Models struggle with timing of AR passage (and end to heavy rain) as sub-synoptic scale waves and interaction with terrain can cause significant model timing errors
 - Models seem to resolve to first approximation moisture flux but underestimate how efficient the cloud is in precipitating the moisture out especially in coastal mountains.
 - Best approach appears to be continuity utilizing upstream ARO measurements - emphasize need for a “picket fence” of AROs along West Coast
 - Unless AR stalls!!!

- Flux Product:

[http://www.esrl.noaa.gov/psd/data/obs/
archive/ImageDocs/UpslopepwFlux.jpg](http://www.esrl.noaa.gov/psd/data/obs/archive/ImageDocs/UpslopepwFlux.jpg)

Snow Level:

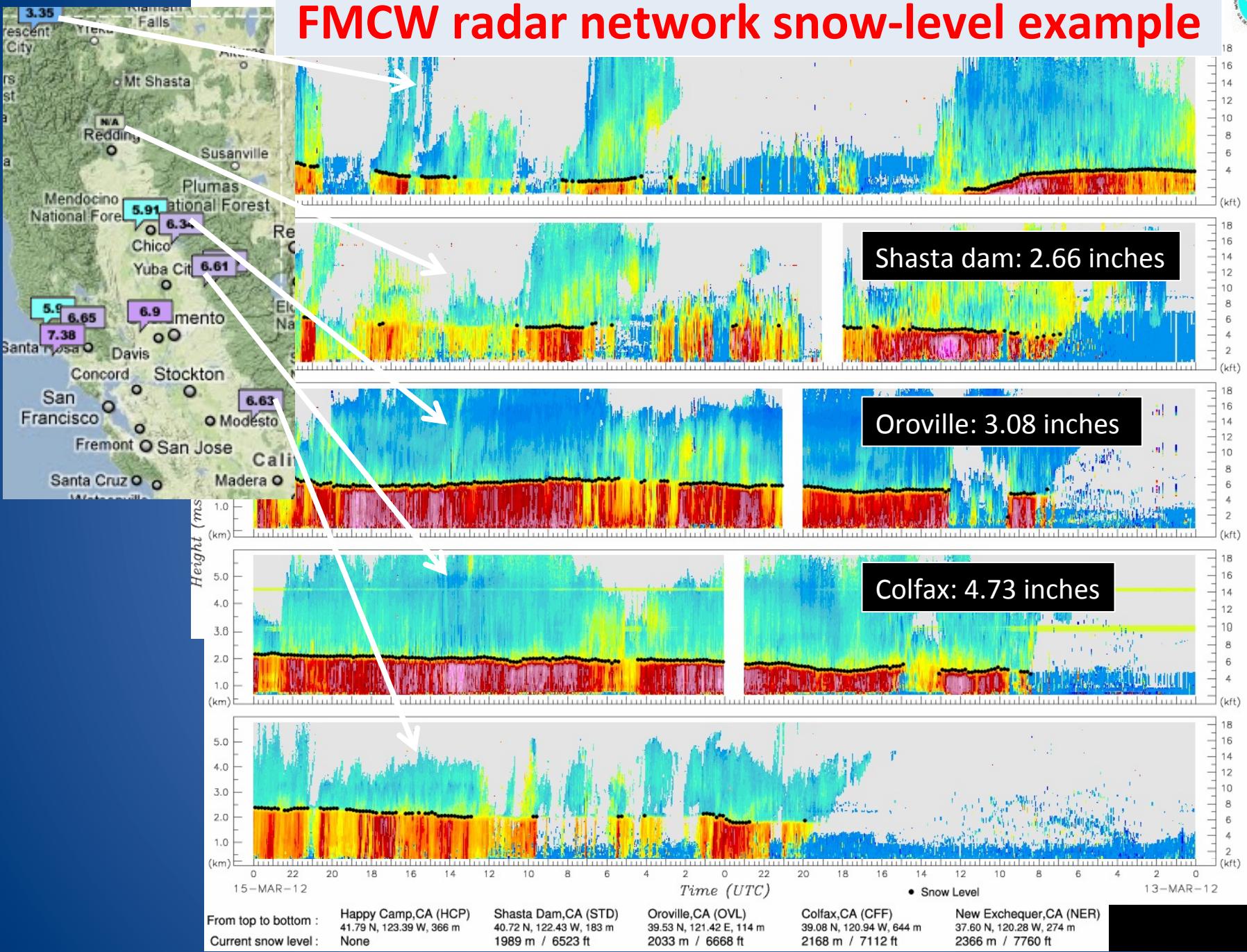
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archive/ImageDocs/SnowLevel.jpg](http://www.esrl.noaa.gov/psd/data/obs/archive/ImageDocs/SnowLevel.jpg)

Winds:

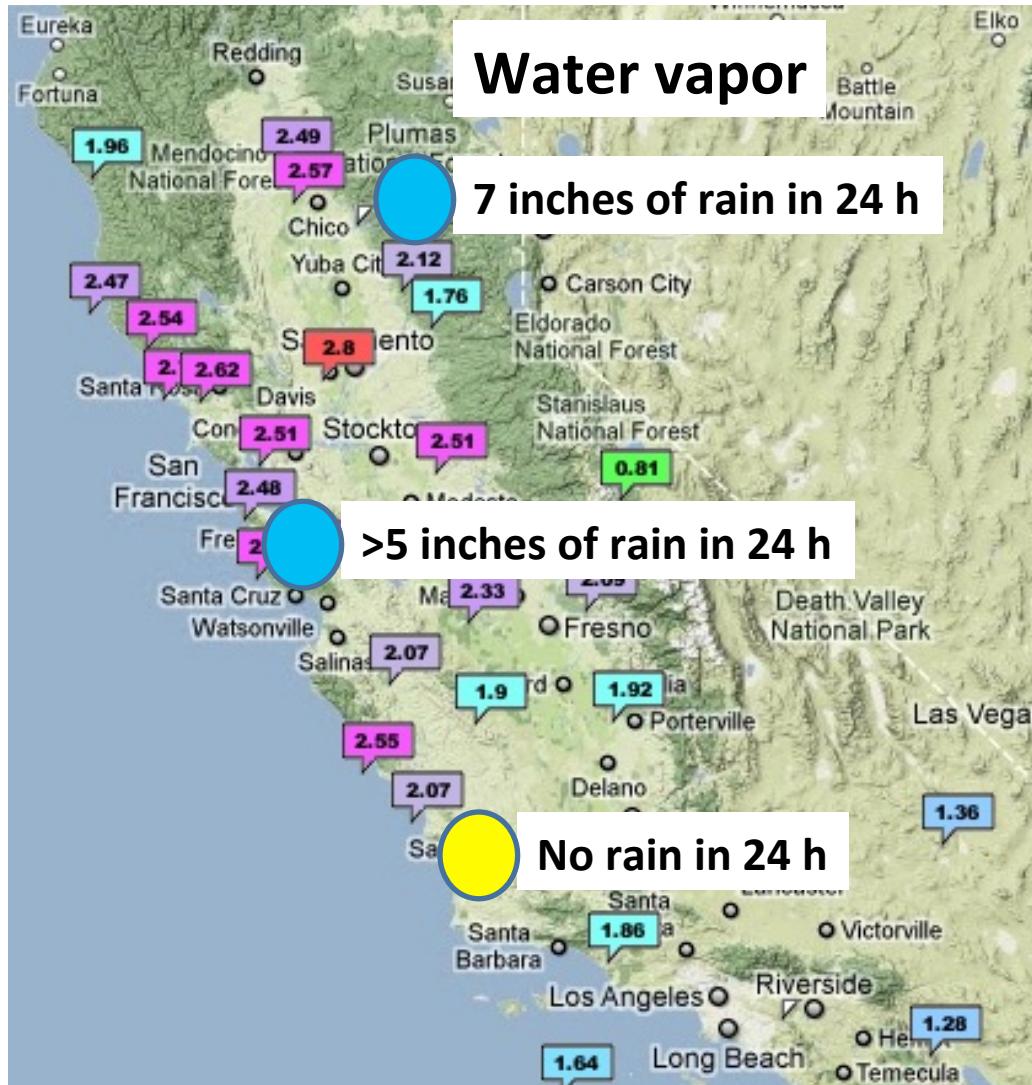
[http://www.esrl.noaa.gov/psd/data/obs/
archive/ImageDocs/WindProfilerWinds.jpg](http://www.esrl.noaa.gov/psd/data/obs/archive/ImageDocs/WindProfilerWinds.jpg)

- Addendum slides

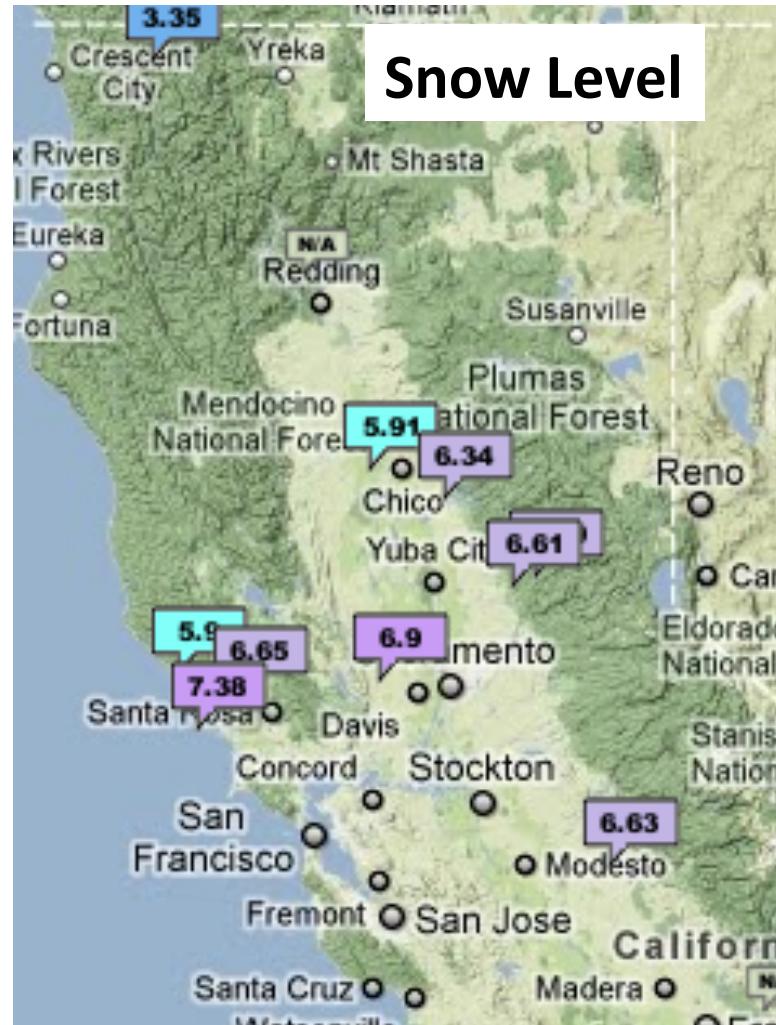
FMCW radar network snow-level example



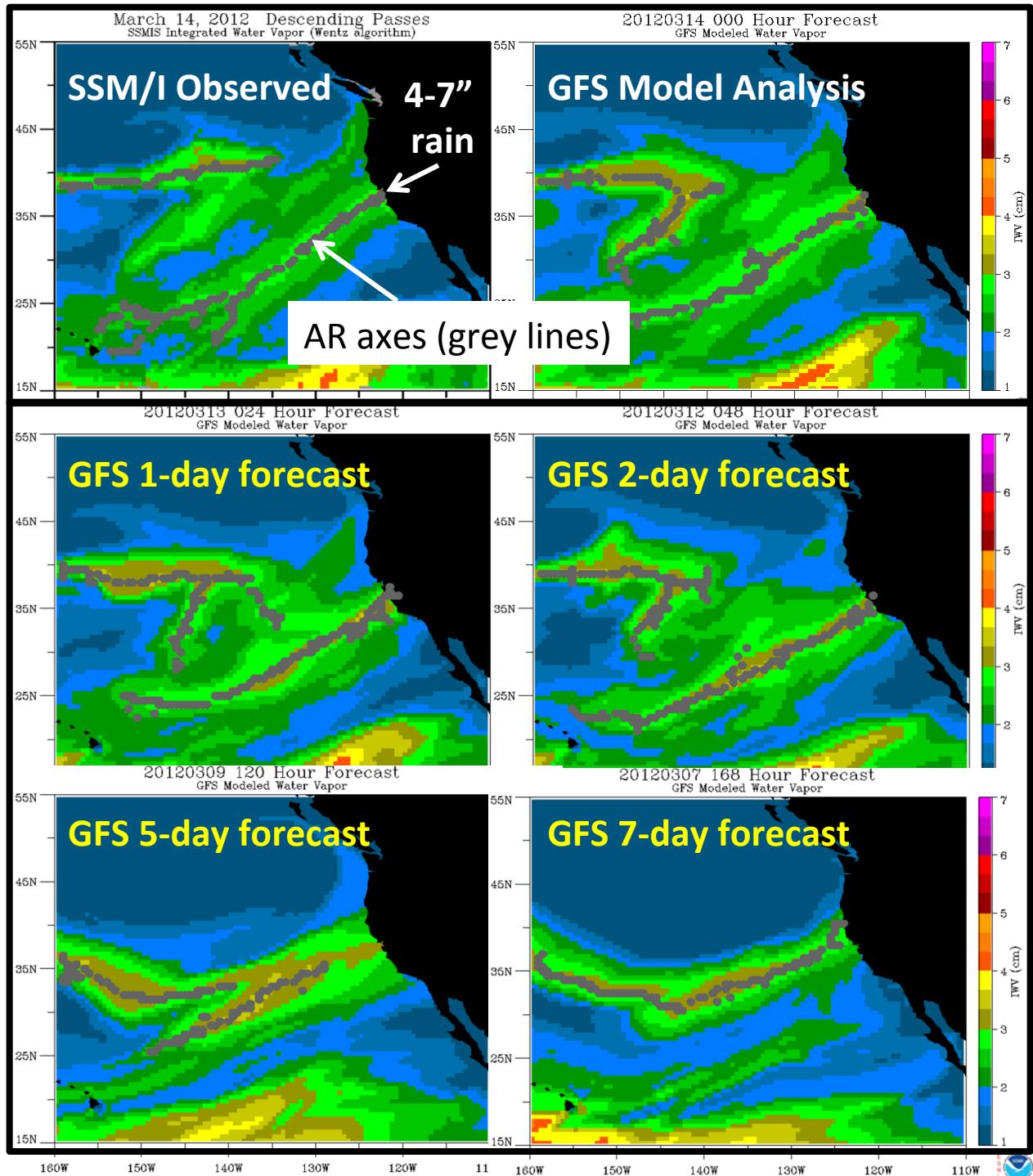
New observations on 13 March 2012



Vertically integrated water vapor (cm)



Snow level observing network showing the "snow level" in 1000's of feet above sea level. The snow level is the altitude above which precipitation is occurring as snow at that place and time.



"AR Detection Tool"

example from
14 March 2012

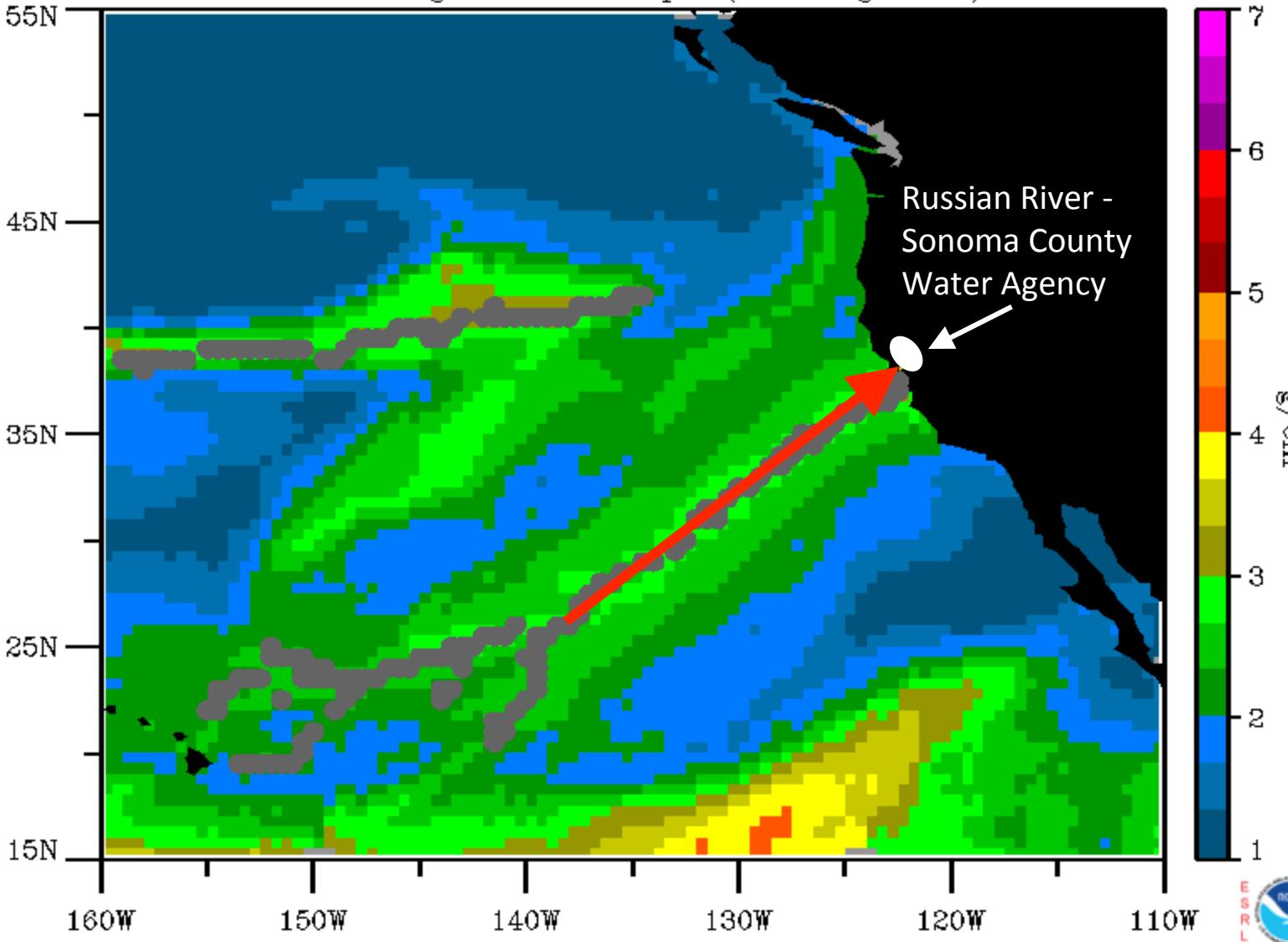
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Satellite observations +
GFS Model analysis

GFS Model Forecasts all
valid at the same time, but
from different lead times

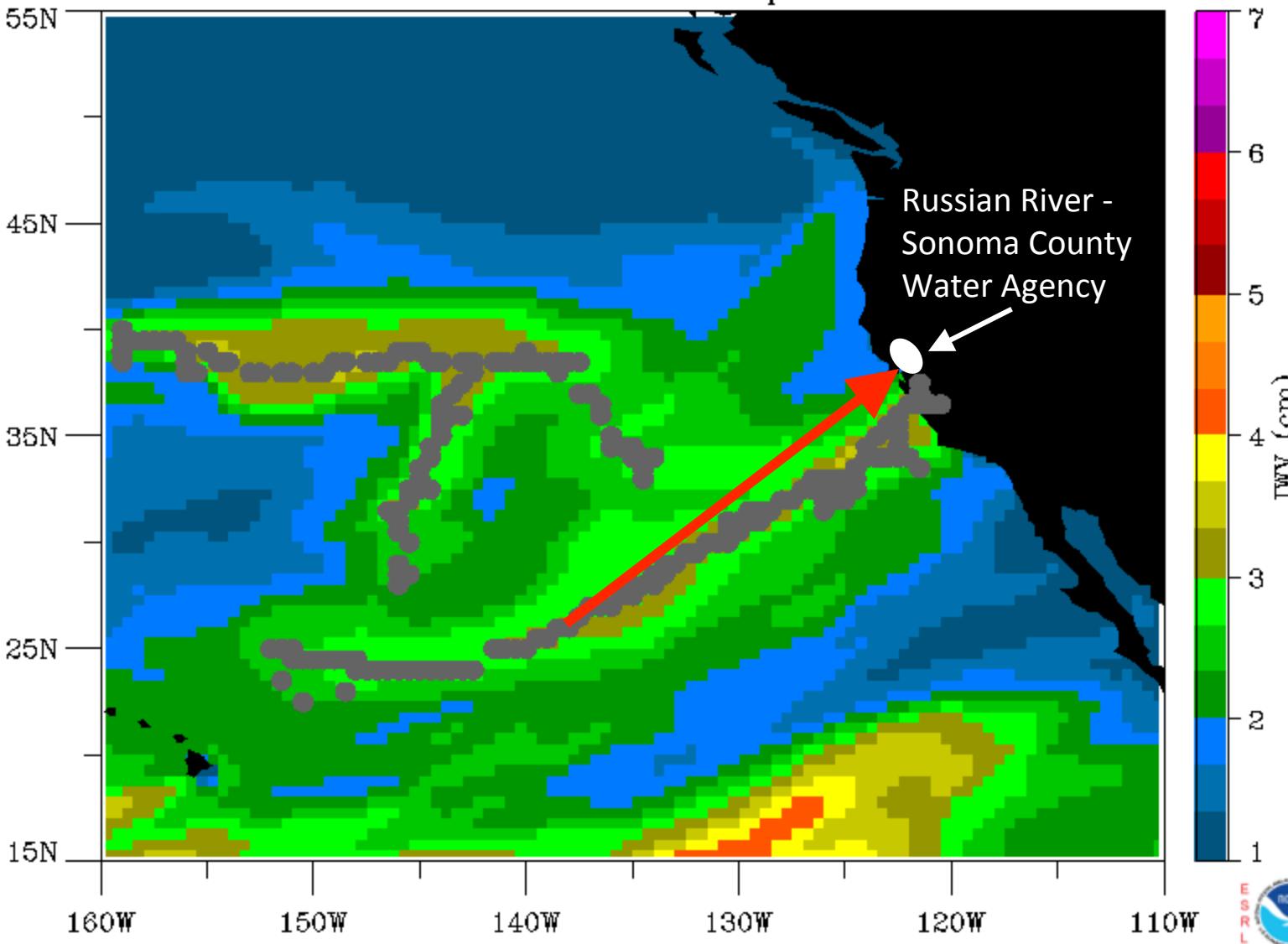
Observed

March 14, 2012 Descending Passes
SSMIS Integrated Water Vapor (Wentz algorithm)



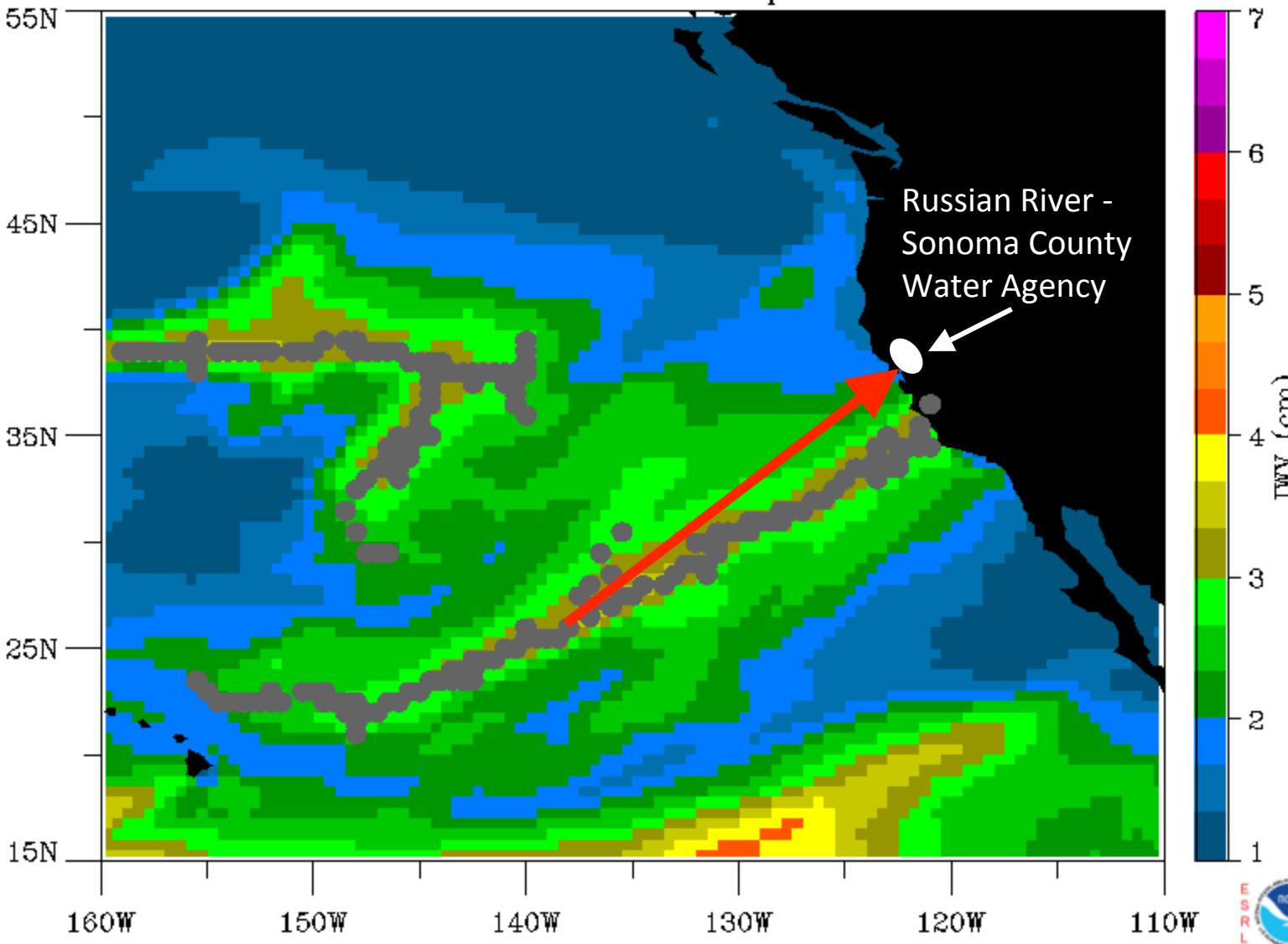
1-day GFS Forecast

20120313 024 Hour Forecast
GFS Modeled Water Vapor



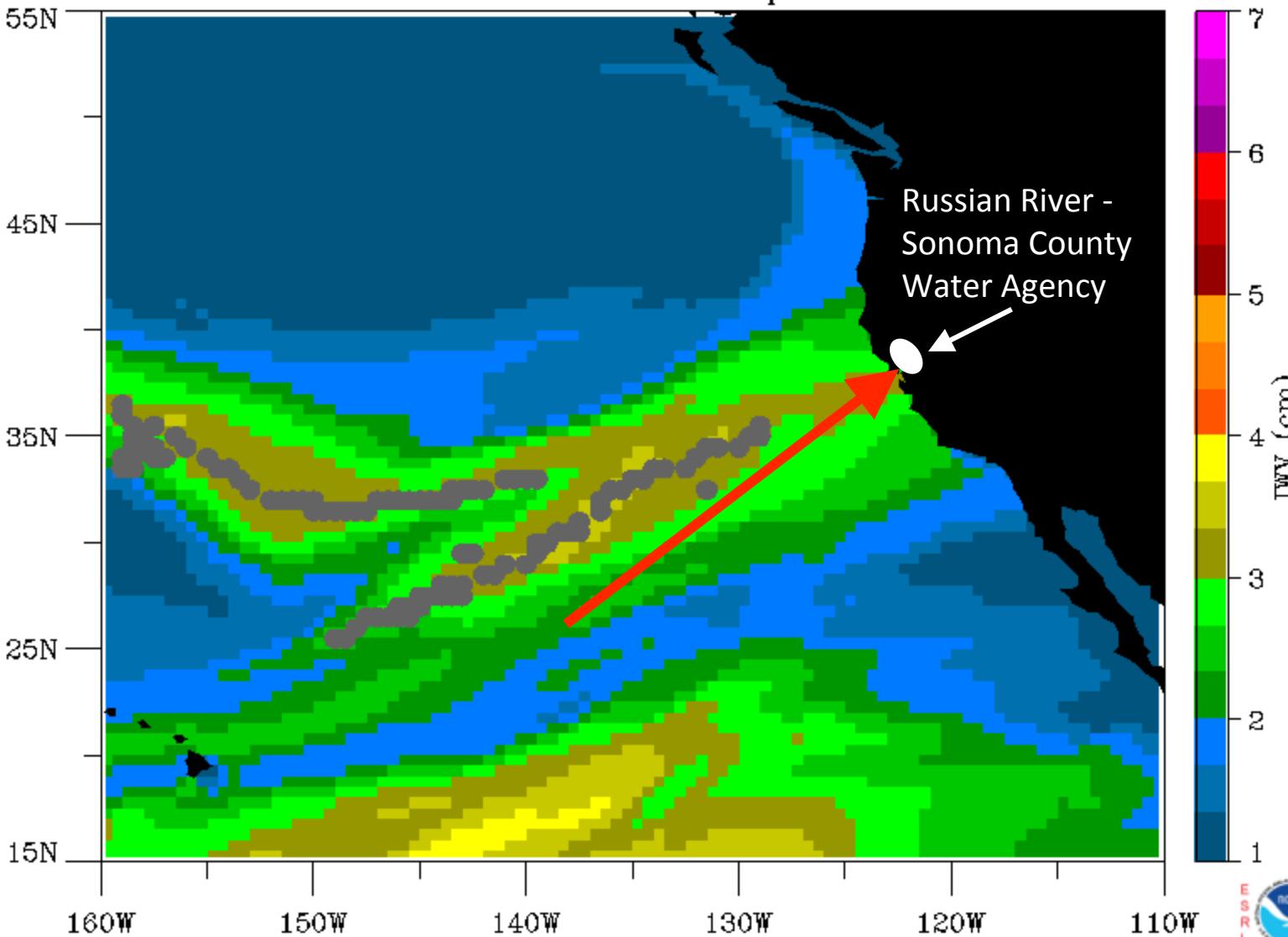
2-day GFS Forecast

20120312 048 Hour Forecast
GFS Modeled Water Vapor



5-day GFS Forecast

20120309 120 Hour Forecast
GFS Modeled Water Vapor



7-day GFS Forecast

20120307 168 Hour Forecast
GFS Modeled Water Vapor

